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HEAT PIPE TECHNOLOGY

A BIBLIOGRAPHY WITH ABSTRACTS

QUARTERLY UPDATE JUNE 30, 1978

TECHNOLOGY APPLICATION CENTER
THE UNIVERSITY OF NEW MEXICO
ALBUQUERQUE, NEW MEXICO 87131

HEAT PIPE TECHNOLOGY

A BIBLIOGRAPHY WITH ABSTRACTS

QUARTERLY UPDATE

APRIL-JUNE 1978

ASSEMBLED BY

THE HEAT PIPE INFORMATION OFFICE

OF

THE TECHNOLOGY APPLICATION CENTER
INSTITUTE FOR APPLIED RESEARCH SERVICES
THE UNIVERSITY OF NEW MEXICO
ALBUQUERQUE, NEW MEXICO

JULY 1978

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INTRODUCTION

This is the second quarterly update for 1978 in the Heat Pipe Technology Bibliographic series.

The major portion of this quarter's activity has been in the area of heat pipe applications for heat recovery and solar energy related systems. There also continues to be considerable activity in heat pipe applications for the aerospace industry. An increased number of publications in the area of heat pipe testing and operation are also cited in this update.

A library containing some of the articles and publications referenced in this bibliographic series has been established and the Center will, on a cost-recovery basis, aid readers to obtain copies of any cited material. Although a considerable effort has been made to insure that the bibliography is complete, readers are encouraged to bring any omissions to the attention of this Center.

Darryl L. Noreen
Editor

CONTENTS

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A number of features have been incorporated to help the reader use this document. They consist of:

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I. GENERAL INFORMATION, REVIEWS, AND SURVEYS

HP78 10006 HEAT PIPES

Duminil, M.M., (Inst. Fr. Froid Ind. Ec. Cent. Arts Mfg., Paris, France), Rev. Gen. Froid., V 68:119-132, 1977
No abstract available

(APPLICATIONS, REVIEW, THEORY)

HP78 10007 HEAT PIPE APPLICATIONS WORKSHOP

Ranken, W.A., (Los Alamos Scientific Lab., Los Alamos, NM), Conf. Proc., Oct. 20-21, 1977, LA-7229-C
Avail:TAC

The proceedings of the Heat Pipe Applications Workshop, held at the Los Alamos Scientific Laboratory, are reported. This workshop, which brought together representatives of the Department of Energy and of a dozen industrial organizations actively engaged in the development and marketing of heat pipe equipment, was convened for the purpose of defining ways of accelerating the development and marketing of heat pipe technology. Recommendations from the three study groups formed by the participants are presented. These deal with such subjects as: (1)the problem encountered in obtaining support for the development of broadly applicable technologies, (2)the need for applications studies, (3)the establishment of a heat pipe technology center of excellence, (4)the role the Department of Energy might take with regard to heat pipe development and application, and (5)coordination of heat pipe industry efforts to raise the general level of understanding and acceptance of heat pipe solutions to heat control and transfer problems.

(APPLICATIONS, CONFERENCE, COORDINATION OF EXPERTISE, SUPPORT FOR HEAT PIPE TECHNOLOGY)

HP78 10008 HEAT PIPES: Volume 3, March 1977, CITATIONS FROM THE NTIS DATA BASE

Reed, W.E., Ed., NTISearch, NTIS/PS-77/0275/6ENS, Search period covered March 1976-March 1977, Publ. by Nat'l Tech. Inf. Service, Springfield, VA, May 1977

Theory, design, fabrication, testing, and operation of heat pipes are presented in these federally sponsored research reports. Applications are described in the areas of heating and air conditioning, power generation, electronics cooling, spacecraft, nuclear reactors, cooling

engines, and thermodynamics. This updated bibliography contains 87 abstracts, all of which are new entries to the previous edition, and covers the period March 1976 through March 1977.

(OVERVIEW, THERMODYNAMICS)

II. HEAT PIPE APPLICATIONS

II. A. GENERAL APPLICATIONS

HP78 20002 STIMULATED ELECTRONIC RAMAN SCATTERING IN CS VAPOUR, A SIMPLE TUNABLE LASER SYSTEM FOR THE 2.7 to 3.5 MICRON REGION

Cotter, D., Hanna, D.C., (Southampton Univ., Southampton, England), Optical and Quantum Electronics, V 9:590-518, Nov. 1977, Research supported by the Paul Instrument Fund and Science Research Council, A78-12440

Stimulated electronic raman scattering (SERS) in atomic vapors provides a simple method of extending the tuning ranges of pulsed dye lasers well into the infrared region. The special advantages of this technique, in comparison with other types of tunable infrared lasers, are discussed and are illustrated by describing a SERS system, which uses a modest nitrogen laser-pumped dye laser (about 20 kw). This produces infrared radiation tunable from 2.67 to 3.47 microns by SERS in cesium vapor, which is contained in a heat pipe oven. Photon conversion efficiencies of up to 50 percent are obtained. The heat pipe oven design, system operation, and optimization of experimental parameters are described in detail.

(CESIUM VAPOR, PULSED-DYE LASER, TUNING RANGE)

HP78 20003 MATERIAL SELECTION CONSIDERATIONS FOR FLUORIDE THERMAL ENERGY STORAGE CONTAINMENT IN A SODIUM HEAT PIPE ENVIRONMENT

Jacobson, D.L., (Univ. of Arizona, Tempe, AZ), 34 p., Final Rept. June 1-Aug. 1976, Prepared in cooperation with Arizona State Univ., Tempe, AZ, 1977

This contract involved a literature survey to determine the state-of-the-art of materials in a high-temperature Na and vacuum environment as applied to thermal energy storage. It was found that little information exists for materials or heat pipes in the high-temperature (1400 K) Na or vacuum environments. Program recommendations are to perform life tests on candidate materials and Na heat pipes with post-test corrosion analyses. Na wicking parameter must be determined experimentally for accurate heat pipe design.

(LIFE-TESTS, FLUORIDES, SODIUM, WICKS)

HP78 20004 HEAT PIPES GAIN USE IN HEAT TRANSFER

Parker, J.D., (Oklahoma State Univ., Stillwater, OK), Oil Gas J., V 75:89-92, N37, 4 refs, Sept. 5, 1977

This article features the use of heat pipes for pipelining, air preheating, and chemical processing operation operations. More than 100,000 heat pipes were used to prevent pile-support settlement on the Alyeska pipeline.

Without the use of any external energy sources, a frozen zone of soil adjacent to the pipe support is maintained by withdrawing heat from the soil through heat pipes during the winter. Finned aluminum radiators are used to dissipate to the cold winter air the heat removed from the soil surrounding the piling. Basic principles of heat pipes are outlined.

(ALYESKA PIPELINE, FINNED ALUMINUM RADIATORS, PILE-SUPPORT SETTLEMENT)

HP78 20005 CHEMILUMINESCENCE FROM MIXTURES OF $Ba+CO_2$ AND Ba+CO

West, J.B., Poland, H.M., (NBS, Washington, D.C.), NBS-2773155, Pub. in J. Chem. Phys., V 66:2139-2141, N5, March 1, 1977, Final Rept., PB-271 633/OSL

Broad banded chemiluminescence has been detected from the reaction of $Ba+CO_2$ and Ba+CO in a heat pipe. Extending from 500 to 1150 nm, the spectrum of this flame exhibits several prominent peaks. The emitting species has not been identified, however, evidence favors a polyatomic molecule.

(Ba+CO, $Ba+CO_2$, WORKING FLUIDS)

HP78 20006 CAVITATION, Part 1, CAVITATION FLOW, Volume 2, 1974-1977, (A Bibliography with Abstracts)

Adams, G.H., (NTIS, Springfield, VA), NTIS/PS-77/0241/8SL, 137 p., Rept. for 1974-March 1977, supersedes NTIS/PS-76/0164, and NTIS/PS-75/292

The bibliography includes reports on general aspects of cavitating flow. A wide range of theoretical, analytical, and experimental information is presented, involving mathematical analysis, computer programs, and testing. Topics include marine engineering, hydrodynamic and aerodynamic configurations, symmetric and non-axisymmetrical shapes, and measuring technology. Data are given on surface piercing struts, helical inducers, pumps, liquid-metal systems, and Venturi tubes. Applications include dam outlets and spillways, vertical conduits, deep rock drilling, heat pipe stability, water entry, and liquid cryogenic systems. Discussions are made of flow characteristics, noise, nucleate boiling, perturbation problems, and allied subjects. Cavitation related to turbines, propellers, rudders, cavities, and hydrofoils is not included. These topics, and materials on cavitation corrosion and erosion, are covered in other associated bibliographies. (This updated bibliography contains 132 abstracts, 60 of which are new entries to the previous edition.)

(OVERVIEW, STABILITY)

II. B. ENERGY CONVERSION

HP 21007 APPLICATION OF CHEMICAL ENGINEERING TO LARGE SCALE SOLAR ENERGY

Chubb, T.A., Nemecek, J.J., Simmons, D.E., (Nav. Res. Lab., E.O. Hulburt Cent. for Space Res., Washington, D.C.), Sharing the Sun: Solar Tech. in the Seventies, Joint Conf. of the Int. Solar Energy Soc., Am. Sect., and Solar Energy Soc. of Canada, Inc., Winnipeg, Manitoba, Canada, V 7:364-374, 4 refs, Aug. 15-20, 1976, Publ. by Int. Solar Energy Soc., Am. Section, Cape Canaveral, FL

In the Solchem concept, sunlight is converted to chemical energy in disbursed solar furnaces. Products are piped to a central station, where energy is stored as heat-of-fusion. Heat pipe boilers provide on-demand power plant steam.

(BOILERS, HEAT-OF-FUSION, SOLAR FURNACE, SOLCHEM)

HP78 21008 PRODUCTION OF REFINED INTERMEDIATE FUELS WITH HIGH-TEMPERATURE REACTORS

Nowacki, P.J., (Int. Atomic Energy Agency, Vienna, Austria), Int. Conf. on Nuclear Power and its fuel cycles, Salzburg, Austria, May 2, 1977, 20 p., RN CONF-770505-174, Also avail. in French
Avail: In Microfiche only

Power plants can be divided into conventional steam plants, fueled with hard coal, lignite, or liquid fuel; hydroelectric plants and nuclear plants, their chief use was or is the production of electric energy; and in certain cases only, of production of process heat, using steam or hot water for process heat in industry and district heating for residential and commercial purposes. The part played by electricity in the whole energy demand is of the order of 10 to 25 percent the total demand; the rest is necessary for supplying process heat below 200 C or above 200 C, up to some 1500 C. Manmade fuels, whether in a gaseous or liquid phase, contain hydrogen, and one can believe, the world is entering a new energy civilization in utilizing hydrogen and its compounds as second energy vector. The author has taken up the task to investigate this new problem of process, heat in the form of hydrogen and its compounds, by evaluating their present and future production, based on the utilization of natural gas , oil, coal, water, and the nuclear heat of helium, available in a closed circuit as primary coolant in a high-temperature helium-cooled reactor. The paper deals in more detail with the following application of nuclear heat: hydrogasification, direct reduction of ore, mainly iron ores, ammonia synthesis, methanol synthesis hydrocracking, long distance transfer of process heat (chemical heat pipe), hydrogenation of coal, Fischer-Tropsch synthesis, oxosynthesis, coal gasification, coal

liquefaction, water splitting (thermolysis) and electrolysis. The various chemical reactions are discussed. Economic and geographical distribution of various kinds of process heat are briefly discussed.

(CHEMICAL HEAT-PIPE, PROCESS HEAT)

HP78 21009 THERMAL ENERGY TRANSFORMER

Berdahl, C.M., Thiele, C.L., (NASA, Pasadena Office, Pasadena, CA), Patent Application, NASA-CASE-NPO-14058-1, PAT-APPL-824-024, 13 p., 1977, N77-30606/5SL
Avail:NTIS

A thermal energy transformer is described for use in combination with a heat engine. It comprises a flux receiver, having a first wall defining therein a radiation absorption cavity for converting solar flux to thermal energy characterized by a first wall defining a radiation absorption cavity having a solar flux energy aperture, and a second wall defining an energy transfer wall for the heat engine, and a heat pipe chamber interposed between the first and second walls having a working fluid disposed within the chamber and a wick lining the chamber for conducting the working fluid from the second wall to the first wall, whereby thermal energy is transferred from the radiation absorption cavity to the heat engine.

(HEAT ENGINE, HEAT PIPE CHAMBER, SOLAR RADIATION)

II. C. ENERGY CONSERVATION, SOLAR, NUCLEAR, AND OTHER ENERGY SYSTEMS

HP78 22025 HEAT EXCHANGERS

Anonymous, Eng. Mater. Des., V 21:23-28, N10, Oct. 1977

Principles of heat transfer of pool boiling and convective boiling as applied in the design of indirect exchangers, direct exchangers, air-cooled exchangers, and heat pipes are discussed.

(CONVECTIVE BOILING, POOL BOILING)

HP78 22026 THERMAL ENERGY TRANSFORMER

Berdahl, C.M., Thiele, C.L., (NASA, Pasadena Office, Pasadena, CA), Patent Application, NASA-CASE-NPO-14058-1, PAT-APPL-824-024, 13 p., 1977, N77-30616/5SL
Avail:NTIS

A thermal energy transformer is described for use in combination with a heat engine. It comprises a flux receiver, having a first wall defining therein a radiation absorption cavity for converting solar flux to thermal energy characterized by a first wall defining a radiation absorption cavity having a solar flux energy aperture, and a second wall defining an energy transfer wall for the heat engine, and a heat pipe chamber interposed between the first and second walls having a working fluid disposed within the chamber and a wick lining the chamber for conducting the working fluid from the second wall to the first wall, whereby thermal energy is transferred from the radiation absorption cavity to the heat engine.

(HEAT ENGINE, HEAT PIPE CHAMBER, SOLAR RADIATION)

HP78 22027 ARE HEAT PIPES UNDER CONTROL?

Brisbane, T.W.C., (National Engineering Lab.), Icheme Symp. on Heat Transfer and Energy Conversion, 8 refs, 1976
Avail:TAC

The use of heat pipes and thermosiphons in gas-to-gas recuperators is described, along with the control of heat transfer rates for various applications.

(APPLICATIONS, HEAT TRANSFER, MATERIALS, REVIEW, WORKING FLUID)

HP78 22028 HEAT RECOVERY DEVICES FOR BUILDING HVAC SYSTEMS

Howell, R.H., Sauer, H.J.Jr., (Dept. of Mechanical and Aerospace Engng., Univ. of Missouri, Rolla, MO)
Avail:TAC

The opportunities and advantages of air-to-air recovery are described. The five basic types (rotary regenerative, coil loop run-around, open run-around, heat pipe, and plate type) are described and their typical perofrmance is presented. The potential savings in operating costs, as well as initial equipment costs for common applications are presented.

(APPLICATIONS, ECONOMICS, EQUIPMENT, HEAT RECOVERY)

HP78 22029 IMPROVEMENT IN GRAIN-DRYER FUEL EFFICIENCY THROUGH HEAT RECOVERY

Lai, F.S., Foster, G.H., (USDA, Agric. Res. Serv., Manhattan, KS), Trans. Am. Soc. Agric. Eng., Gen. Ed., V 20:579-584, N3, 15 refs, May-June 1977

Grain drying is an energy-intensive operation from which useful heat is discarded. Recovery and reuse of part of this heat appears feasible. A heat-pipe heat exchanger, singly and incombination with a heat pump, was tested experimentally and by mathematical simulation as an approach to heat recovery and reducing energy requirements for grain drying.

(AGRICULTURE, FUEL ECONOMY, HEAT EXCHANGER)

HP78 22030 AN INTERNAL CUSP REFLECTOR FOR AN EVACUATED TUBULAR HEAT PIPE SOLAR THERMAL COLLECTOR

Ortabasi, U., Buehl, W.M., (Corning Research and Development Lab., Corning, NY), In International Solar Energy Society, Annual Meeting, Orlando, FL, Proc., p. 36-30 to 36-36, June 6-10, 1977, sections 26-38, A78-11212 01-44, Int. Solar Energy Soc., Cape Canaveral, FL, A78-11384

This study involves optical analysis of a slightly concentrating symmetric cusp reflector inside a tubular glass envelcpe with a cylindrical heat pipe as the solar absorber. The basic design features of this nontracking evacuated modular collector and the principles of heat removal are described. Differential equations of the cusp reflector optics are derived, and solutions for the largest possible aperture inside a given diameter envelope and acceptance angle are presented. The optical efficiency of a single collector tube has been simulated by means of a Monte Carlo ray-tracing program. For a concentration ratio of 1.15, the flux distribution around the heat pipe is computed as a function of incidence angle. In addition, the impact of mirror defects and absorber misalignment on optical performance is analyzed.

(DESIGN, HEAT REMOVAL, OPTICAL ANALYSIS, OPTICAL EFFICIENCY)

HP78 22031 FUNDAMENTAL EXPERIMENT OF POTASSIUM HEAT EXCHANGER USING PRINCIPLE OF HEAT PIPE

Sumida, I., Kotani, K., (Hitachi, Ltd., Ozenji, Kawasaki-shi, Japan), J. Nucl. Sci. Tech., V 13:648-655, N1, 8 refs, Nov. 1976

A potassium heat exchanger, features separate construction of primary and secondary coolant systems. A small amount of potassium plays a role as an intermediate media of heat transportation. Heat is transferred by evaporation and condensation of potassium on the surfaces of the primary and secondary coolant pipings, respectively. The tests were performed in the temperature range of 200 to 300 C and the maximum heat transfer reaches 1.3 KW (heat transfer rate at the primary heating source: 8.6 W/cm^2 at 300 C).

(NUCLEAR SYSTEMS, REACTOR COOLING)

HP78 22032 REACTOR TECHNOLOGY, Progress Report, April-June 1977

Warren, J.L., (Los Alamos Scientific Lab., Los Alamos, NM), Aug. 1977, X78-0021012

Progress is reported in eight program areas. Steady progress has been made on defining the design of space electric power supply (SEPS) components. There have been three significant advances in heat pipe technology. Criteria have been set forth for the selection of compatible combinations of ceramics and metal.coats for heat pipes. A system to avoid molecular absorption of the laser light in sodium vapor lasers was devised and tested. A mercury heat pipe to remove heat from stored fuel elements is being fabricated. Work continues on the evaluation of computer codes used in the analysis of gas-cooled nuclear reactors to be used for nuclear process heat. Work is nearly complete on a model of a gas core reactor power plant. Criticality experiments are being run in the plasma core critical assembly. Several other critical assemblies are in routine use for verifying calculations and supporting research being done by other groups in the laboratory. Several criticality safety studies and reviews were made. Work has begun on a proposal for developing an electro-nuclear fuel producer (ENFP).

(CRITICALITY, FUEL ELEMENTS, MERCURY HEAT-PIPE)

HP78 22033 HEAT TRANSFER IN SOLAR ENERGY STORAGE, USING UNPREPARED EARTH AS STORAGE MEDIUM

Yuan, S.W., Bloom, A.M., Nazli, M., (George Washington Univ., Washington, D.C.), Am. Inst. of Chem. Engrs. and Am. Soc. of Mech. Engrs., Heat Transfer Conf., Salt Lake City, UT, 11 p., Aug. 15-17, 1977, ASME, Paper 77-HT-38, Members $1.50, Nonmembers $3.00, A78-17487

An analysis of the heat transfer characteristics of a solar energy storage concept that used unprepared earth as a storage medium is presented. Two methods of heating and extraction are considered. The first method uses a water pipe heat exchanger for both the heating and extraction phases. The second method uses a heat pipe during the heating phase and a water pipe during the extraction phase. The heat input to the earth storage is obtained by the operation of solar collectors. The solar collection process is activated during the day and is deactivated during the night. Solar energy is collected by this procedure throughout the entire year and stored in the earth reservoir. For space heating applications, house load data are applied to the earch storage during the winter months. It is demonstrated that year-round solar collection and approximately 400,000 ft^3 of earth storage is adequate to

provide space heating for 12 average size houses in most areas of the United States. Furthermore, the use of a heat pipe on the heating phase may reduce the initial preparation time for the earth storage.

(CHANGING, EXTRACTION, PERFORMANCE)

HP78 22034 HEAT RECOVERY

Piper, J.E., Building Operating Management, p. 44-49, March 1978
Avail:TAC

A number of different systems are available for recov recovering and reusing heating and cooling energy. The operation of a heat pipe is described, along with the operation of a heat pipe air-to-air heat exchanger and its economic feasibility in heat recovery applications.

(ECONOMICS, WASTE-HEAT RECOVERY)

HP78 22035 APPLICATION OF CHEMICAL ENGINEERING TO LARGE SCALE SOLAR ENERGY

Chubb, T.A., Nemecek, J.J., Simmons, D.E., (Nav. Res. Lab., E.O. Hulburt Cent. for Space Res., Washington, D.C.), Sharing the Sun: Solar Tech. in the Seventies; Joint Conf. of the Int. Solar Energy Soc., Am. Sect., and Solar Energy Soc. of Canada, Inc., Winnipeg, Manitoba, Canada, V 7:364-374, 4 refs, Aug. 15-20, 1976, Publ. by Int. Solar Energy Soc., Am. Sect., Cape Canaveral, FL

In the Solchem concept, sunlight is converted to chemical energy in disbursed solar furnaces. Products are piped to a central station, where energy is stored as heat-of-fusion. Heat pipe boilers provide on-demand power plant steam.

(BOILERS, HEAT-OF-FUSION, SOLAR FURNACE, SOLCHEM)

HP78 22036 HEAT PIPE MATERIALS, UNIQUE REQUIREMENTS FOR COAL GASIFICATION PROCESSES

Ewell, G.J., Basiulis, A., (Hughes Aircraft Co., Culver City, CA), Nat'l Sampe. Symp. Exhib., V 22:454-465, 1977

No abstract available

(CAUSTIC ENVIRONMENT, PROCESSES)

HP78 22037 CONTRIBUTION ON APPLYING THE HEAT PIPE IN VENTILATION AND AIR CONDITIONING

Richter, W., (Tech. Univ., Dresden, E. Germany), Luft Kaeltetech., V 13:197-203, N4, 10 refs, 1977, In German with English abstract

The paper describes the mode of operation and design features of normal and special developments of low-temperature heat pipes. The most important calculation equations for selected types are presented in a summarized manner. Referring to the problems of heat transmission on the internal and external surfaces, the applications of the heat pipes in ventilation and air conditioning are discussed.

(EQUATIONS, HEAT TRANSFER, LOW-TEMPERATURE, REVIEW)

II. D. AEROSPACE APPLICATIONS

HP78 23010 PERFORMANCE OF THE 12GHZ, 200-WATT TRANSMITTER EXPERIMENT PACKAGE FOR THE HERMES SATELLITE

Alexovich, R.E., (NASA, Lewis, Cleveland, OH), NASA-TM-73804 E-9385, 34 p., Presented at Symp. on Hermes (Communications Tech. Satellite), Ottawa, Canada, Nov.-Dec. 1, 1977, Spons. by Royal Soc. of Canada, Canadian Dept. of Communications, and NASA, N-78-13282

Performance characteristics from on-orbit tests of the transmitter experiment package (TEP) for the Hermes satellite are presented. The TEP consists of a power-processing system (PPS), an output stage tube (OST), and a variable conductance heat pipe system (VCHPS), all of which are described. The OST is a coupled-cavity traveling wave tube (TWT) with a multi-stage depressed collector (MDC) and a stepped velocity-tapered slow wave structure for efficiency enhancement. It has an RF output power of 233 watts and overall efficiency of 50.75 percent at a center band frequency of 12.080 GHZ. The PPS provides the required operating voltages, regulation, control, and protection for the OST. The VCHPS consists of a fin radiator and three dual-artery stainless steel heat pipes, using methanol and a mixture of inert gases. Test results presented include efficiencies, RF output power, and body current. A discussion of thermal anomalies which occurred is presented.

(HEAT-PIPE, INERT GASES, METHANOL, STAINLESS STEEL, VARIABLE CONDUCTANCE)

HP78 23011 PACKAGING OF A LARGE-CAPACITY MAGNETIC BUBBLE DOMAIN SPACECRAFT RECORDER

Becker, F.J., Stermer, R.L., (Rockwell Int., Anaheim, CA), Dig. Pap. IEEE Comput. Soc., Int. Conf., 14th, San Francisco, CA, p. 258-262, Feb. 28-March 3, 1977, IEEE, New York, NY, Cat. no. 77CH1165-0 C

A Solid-State Spacecraft Data Recorder (SSDR), based on bubble domain technology, having a storage capacity of 10^6 bits, has been designed and is currently being tested. The SSDR weighs approximately 47 pounds, occupies 860 in^3 and is conduction cooled. Polymeric materials have been selected to meet thermal vacuum and heat sterilization requirements. Structural design is based on environmental and thermal considerations. Heat pipes are used extensively throughout the system to reduce weight and improve thermal performance.

(CONDUCTION COOLED, POLYMERIC MATERIALS, SOLID STATE)

HP78 23012 ANALYSIS AND RADIANT HEATING TESTS OF A HEAT PIPE-COOLED LEADING EDGE

Camarda, C.J., (NASA Langley Res. Center, Hampton, VA), NASA-NASA-TN-D-8468, Aug. 1977, NASA, Washington, D.C., L-11247 Avail:TAC

The performance of a heat pipe-cooled leading edge was investigated experimentally and analytically. The test model and radiant heaters were positioned to simulate aerodynamic heating distributions and gravity effects at angles of attack of 0, 10, and 20. Steady-state stagnation heating ranged from 239 KW/m^2 (21.1 BTU/ft^2-sec) to 395 KW/m^2 (34.8 BTU/ft^2-sec) with heat pipes operating at temperatures of 883 K (1130 F) and 922 K (1200 F), respectively. A simple analytical technique was used to determine startup, transient, and steady-state performance of the heat pipes during testing. Experimental results agreed well with calculated results for the thermal behavior of the leading edge. Results verified successful operation of the leading edge for all tests, including the design condition, which simulated the re-entry heating environment of a Phase B shuttle orbiter.

(HEAT TRANSFER, RE-ENTRY HEATING, SPACE SHUTTLE, TEMPERATURE CONTROL)

HP78 23013 ADVANCED SPACECRAFT THERMAL CONTROL TECHNIQUES

Fritz, C.H., (NASA, Marshall Space Flight Center, Huntsville, AL), NASA-TM-78134, 80 p., 1977, N78-10414/8SL

The problems of rejecting large amounts of heat from spacecraft were studied. Shuttle space laboratory heat rejection uses 1 KW for pumps and fans for every 5 KW (thermal) heat rejection. This is rather inefficient, and

for future programs, more efficient methods were examined. Two advanced systems were studied and compared to the present pumped-loop system. The advanced concepts are the air-cooled semi-passive system, which features rejection of a large percentage of the load through the outer skin, and the heat pipe system, which incorporates heat pipes for every thermal control function.

(HEAT RADIATORS, HEAT REJECTION)

HP78 23014 DESIGN AND DEVELOPMENT OF A GAS-CONTROLLED HEAT PIPE RADIATOR FOR COMMUNICATION SPACECRAFT APPLICATIONS, Phase 2

Kreeb, H., (Dornier-System G.M.B.H. Friedrichshafen, W. Germany), ESA-CR(P)-958, 200 p., 1977, ESTEC-2464/75-PP, N77-32452/3SL

The manufacture and thermal testing of a gas-controlled heat pipe radiator is dealt with. The temperature of a central plate, provided with eight separate heaters, is stabilized by heat pipes of the cold gas reservoir type. The heat pipes were tested in the passive, and after a slight modification, active mode. The manufacture of the radiator and its equipment was carried out according to detailed procedures. The radiator was fitted with 134 copper-constantan thermocouples and 51 separate heaters. Part of the radiator manufacture was the inert gas filling procedure. The thermal radiator tests included a performance test in passive and in active mode (feedback), and life tests in vacuum and in atmosphere. Test results generally agreed well with predictions.

(GAS-CONTROL, LIFE TEST, MANUFACTURE, MODE, TEST)

HP78 23015 HIGH-TEMPERATURE, HIGH-POWER DENSITY THERMIONIC ENERGY CONVERSION FOR SPACE

Morris, J.F., (NASA, Lewis, Cleveland, OH), NASA-TM-73844 E-9431, N78-13890

Theoretic converter outputs and efficiencies indicate the need to consider thermionic energy conversion (TEC) with greater power densities and higher temperatures within reasonable limits for space missions. Converter-output power density, voltage, and efficiency as functions of current density were determined for 1400-to-2000 K emitters with 725-to-1000 K collectors. The results encourage utilization of TEC with hotter-than-1650 K emitters and greater-than-6W/cm^2 outputs to attain better efficiencies, greater voltages, and higher waste-heat rejection temperatures for multihundred-KW space power applications. For example, 1800 K, 30/cm^2 TEC operation for NEP compared with the 1650 K, 5/cm^2 case should allow much lower

radiation weights, substantially fewer and/or smaller emitter heat pipes, significantly reduced reactor and shield-related weights, many fewer converters and associated current-collecting busbars, less power conditioning, and lower transmission losses. Integration of these effects should yield considerably reduced NEP specific weights.

(CURRENT DENSITY, EFFICIENCY, NUCLEAR REACTOR)

HP78 23016 LIFETESTS OF THE TELECOMMUNICATIONS SATELLITE HEAT PIPES, Final Report

Muenzel, W.D., (Stuttgart Univ., Energy Conversion and Heat Transfer Div., Stuttgart, W. Germany), N78-13398

Test results obtained during lifetests of heat pipes throughout a period of three years are described, together with the instrumentation and the test setup. Bendable seven mm O.C. artery heat pipes have been developed for satellite applications. Four of these heat pipes subjected to a stationary lifetest were operating with a heat load of 15 watts at a temperature of 60 C, and another one, the accelerated lifetest heat pipe, was operated in reflux boiler mode at a temperature of about 100 C. A sixth heat pipe underwent a thermal shock test, consisting of 3000 cycles between 5 C and 80 C. During the lifetests, gas generation within all of the heat pipes was detected, resulting in a steadily increasing length of blocked condenser section. Due to the degrading long-term performance of the Al-SS-NH_3 heat pipes, some of these were replaced by one-metal heat pipes made from stainless steel. The lifetest of three heat pipes was discontinued prior to the planned lapse of three years. These heat pipes were cut open to analyze working fluid and any deposits on the inner heat pipe surfaces.

(ALUMINUM, AMMONIA, EVALUATION, GAS GENERATION, STAINLESS STEEL)

HP78 23017 DEVELOPMENT OF A STAINLESS STEEL AXIALLY GROOVED LOW-TEMPERATURE LIQUID-TRAP DIODE HEAT PIPE, Final Report

Suelau, H.J., (B and K Engng., Inc., Towson, MD), P.O. no. A-39958-B (DG)
Avail:TAC

The objective of this program is to develop an axially grooved heat pipe, which is compatible with a liquid-trap diode design. The axially grooved heat pipe was fabricated from stainless steel tubing to provide a high-strength, low-conductance envelope to minimize axial conduction effects, and charged with ethane for testing at 100 K. The heat pipe's diode operation accomplished by the liquid-trap technique served to effectively "shutdown" the heat pipe during reversal.

(ETHANE, HPEP, RECOVERY, SHUTDOWN, START-UP)

HP78 23018 EARLY PERFORMANCE OF THE 12-GHZ, 200-WATT TRANSMITTER EXPERIMENT PACKAGE IN THE COMMUNICATIONS TECHNOLOGY SATELLITE

NASA, Lewis, Cleveland, OH, NASA-TM-X-3555 E-9104,66 p., 1977 N77033258/3SL

Measured performance characteristics of the transmitter experiment package (TEP) aboard the communications technology satellite for the first 90 operating days in orbit are presented. The TEP consists of a nominal 200-watt output stage tube (OST), a supporting power-processing system (PPS), and a variable-conductance heat pipe system (VCHPS). The OST, a traveling-wave tube augmented with a 10-stage depressed collector, has an overall saturated average efficiency of 51.5 percent and an average saturated radio-frequency (RF) output power at center-band frequency of 240 watts. The PPS operated with a measured efficiency of 86.5 percent to 88.5 percent. The VCHPS, using three pipes to conduct heat from the PPS and the body of the OST to a 52-cm x 124-cm (20.5-in x 48.75-in) radiator fin, maintained by the PPS baseplate temperature below 50 C for all operating conditions. The TEP performance characteristics presented include frequency response, RF output power, efficiency, and distortions. Communications characteristics were evaluated by using both video and audio-modulated signals.

(DISTORTIONS, EFFICIENCY, FREQUENCY, OUTPUT POWER, RESPONSE, VARIABLE CONDUCTANCE HEAT-PIPE)

II. E. ELECTRICAL AND ELECTRONIC APPLICATIONS

HP78 24001 INDUCTION-MOTOR FAN DRIVE WITH UNLAMINATED ROTOR AND HEAT-PIPE COOLING

Chalmers, B.J., Herman, J., (Univ. of Manchester, Inst. of Sci. and Tech., Manchester, England), Proc. Inst. Electr. Eng., London, England, V 124:449-453, N5, 10 refs, May 1977

A variable-voltage induction-motor fan drive is described, in which the rotor is constructed of hollow unlaminated steel, and is cooled using the rotating heat-pipe principle. A procedure for performance computations is presented, and the special properties of fan drives with unlaminated rotors are demonstrated by both theoretical and tested results for an experimental machine. It is shown that the design successfully overcomes the normal problem of fan drive cooling in the region of slip equal to 1/3. Difficulties associated with losses at low slip are identified, and ways of relieving this problem are examined.

(PERFORMANCE COMPUTATIONS, ROTATING HEAT-PIPE, TESTING)

HP78 24002 SWITCHING POWER TRANSISTORS AND PASSIVE HEAT REMOVERS, A POWER-HANDLING TEAM GEARED TO THE CURRENT NEED FOR ENERGY CONSERVATION

Dilatush, E., V 22:50-62, N10, B77-028864

This report discusses the unique stresses imposed upon switching power transistors, their need for comprehensive specifications, and their specialized construction to reduce heat dissipation. Processing techniques to obtain the required characteristics are considered. Various methods of cooling, including the use of heat pipes, are described. Device selection is considered.

(COMPONENT COOLING, ELECTRONIC, SEMICONDUCTOR)

HP78 24003 USE OF HEAT PIPES IN ELECTRONIC HARDWARE

Graves, J.R., (Electronics and Control Laboratory, Power Branch, NASA, Marshall, Huntsville, AL)
Avail:TAC

The Load Center Converter (LCC) consists of a mainframe chassis with interchangeable, plug-in regulator modules. This common support base accommodates the regulator modules and contains the housekeeping power supply and input filtering. To further improve performance and reduce size and weight, the converter package design utilizes advanced heat-removal techniques, namely heat pipes, to remove internally generated heat more effectively than conventional methods.

(HEAT REMOVAL, LCC, LOAD-CENTER CONVERTER, POWER PROCESSING)

HP78 24004 PACKAGING OF A LARGE-CAPACITY MAGNETIC BUBBLE DOMAIN SPACECRAFT RECORDER

Becker, F.J., Stermer, R.L., (Rockwell Int., Anaheim, CA), Dig. Pap. IEEE Comput. Soc., Int. Conf., 14th, San Francisco, CA, p. 258-262, Feb. 28-March 3, 1977, IEEE, New York, NY, Cat. no. 77CH1165-0 C

A Solid-State Spacecraft Data Recorder (SSDR), based on bubble domain technology, having a storage capacity of 10^6 bits, has been designed and is currently being tested. The SSDR weighs approximately 47 pounds, occupies 860 in^3, and is conduction cooled. Polymeric materials have been selected to meet thermal vacuum and heat sterilization requirements. Structural design is based on environmental and thermal considerations. Heat pipes are used extensively throughout the system to reduce weight and improve thermal performance.

(CONDUCTION COOLED, POLYMERIC MATERIALS, SOLID STATE)

III. HEAT PIPE THEORY

III. A. GENERAL

HP78 30010 CONDENSATION HEAT TRANSFER IN ROTATING HEAT PIPES IN THE PRESENCE OF A NON-CONDENSABLE GAS

Daniels, T.C., Medwell, J.O., (Swansea, Univ. College, Swansea, Wales), Williams, R.J., (NASA, Ames Res. Center, Moffett Field, CA), V 22:497-519, July-Aug., 1977, A78-20304

An analysis of condensation problems in rotating heat pipes containing vapors with different concentrations of non-condensable gases is given. In situations such as this, temperature and concentration gradients are set up in the vapor-gas mixture. There is a transport of mass, due to temperature gradients, accompanied by an energy transport pnenomena, due to a concentration gradient. A Nusselt-type analysis is not suited to this type of problem. However, a boundary layer-type approach has successfully been used to analyze stationary condensation systems with non-condensable gases present. The present boundary-layer analysis is presented for condensation processes on the inside of a rotating heat pipe in the presence of non-condensable gases.

(BOUNDARY LAYER, CONCENTRATION GRADIENT, ENERGY TRANSPORT)

HP78 30011 OSMOTIC HEAT PIPE: PROBLEMS AND PROMISES

Doshi, M.R., (Inst. of Paper Chemistry, Appleton, WI), Eastmen, G.Y., (Thermacore, Inc., Leola, PA), Letters in Heat and Mass Transfer, V 4:429-436, Nov.-Dec. 1977, A78-18074

Various problems associated with the operation of a heat pipe based on osmotic pumping for improved performance are examined. The discussion stresses the concept of osmotic heat pipes and important potential limitations on their performance. The heat pipe encloses a membrane, the annular space is filled with a salt solution, and water permeates by osmosis through the membrane and flows in the annular space. Heat is removed at the bottom and condensed pure water is transported to the membrane by the capillary action of the wick. The limitations are such that heat transfer is limited by membrane permeability, the salt tends to concentrate in the evaporator region rather than the membrane area where it is needed to promote osmosis, the optimum solute concentration must be determined to obtain maximum buoyancy forces without crystallizing the salt, and the condensate must not block the vapor flow. A tentative geometry to meet these conditions is presented.

(GEOMETRY, HEAT SINKS, LIMITATIONS, OSMOTIC PUMPING)

HP78 30012 EFFECT OF HEAT CARRIER QUANTITY ON THE OPERATION OF HEAT PIPES WITH INHOMOGENEOUS CAPILLARY STRUCTURE IN THE ABSENCE OF MASS FORCES

Ivanovskii, M.N., Sorokin, V.P., Privezentsev, V.V., (Gosudarstvennyi Komitet Po Ispol'Zovaniiu Atomnoi Energii, Fiziko-Energeticheskii Institut, Obninsk, USSR), Teplofizika Vysokikh Temperatur, V 15:873-878, July-Aug. 1977, In Russian, A78-12347

No abstract available

(HEAT TRANSFER, THERMAL EFFICIENCY, WORKING FLUID)

III. B. HEAT TRANSFER

HP78 31009 EFFECT OF PRESSURE OF THE INTERMEDIATE HEAT CARRIER ON CRITICAL HEAT FLUXES IN EVAPORATIVE THERMOSIPHONS

Bezrodnyi, M.K., Alekseenko, D.V., (Kiev Polytech. Inst., Ukr SSR), Izv. Vyssh. Uchebn Zaved Energ., p. 80-84, N4, 9 refs, April 1977, In Russian

Results of an experimental investigation of critical heat fluxes in closed two-phase thermosiphons, depending on geometric dimensions of the heat supply section and the pressure of the intermediate heat carrier (F-11, F-12, F-113, and methanol), are presented. The investigations are carried out within the range of pressures from the atmospheric to 0.8 P_{cr}. As a result of generalization of experimental data, it is found that the character of dependence of the critical heat fluxes on the reduced heat pressure P/P_{cr} for the liquids considered is identical and differs but slightly from the appropriate relation for the boiling of liquids under large-volume conditions.

(CRITICAL HEAT-FLUX, HEAT TRANSFER)

HP78 31010 HEAT TRANSFER IN A CENTRIFUGAL HEAT PIPE

Kukharskii, M.P., Krivosheev, B.N., Kosheleva, G.V., Inzhenerno-Fizicheskii Shurnal, V 33:388-392, Sept. 1977, In Russian, A78-18995

The effect of thermal flux density and vapor pressure on heat transfer in a cylindrical centrifugal heat pipe was studied on a calorimetric test setup with convective heat feeding and removal. A copper heat pipe of 2.8-cm inner diameter was tested at a rotation frequency of 96 rev/sec, a mean condensate layer thickness of 0.3 mm, and thermal flux

density in the heat transfer sections of 20-80 KW/m^2. It was found that as the thermal flux density and pressure increased, the rate of heat transfer increased. An empirical formula was obtained for the heat transfer coefficient in the heat transfer zone as a function of the parameters studied.

(CALORIMETRIC TEST, CONVECTION, FLUX DENSITY, VAPOR PRESSURE)

HP78 31011 STUDY OF THE THERMAL RESISTANCE OF A CRYOGENIC HEAT PIPE

Piskunov, V.B., Bartkevich, N.Y., Bakhnev, V.G., Prusman, Y.O., Khim. Neft. Mashinostr., p. 20-21, 1977, USSR
No abstract available

HP78 31012 GENERALIZING RELATIONS FOR LOCAL HEAT TRANSFER COEFFICIENTS DURING TURBULENT FLOW OF WATER AND CARBON DIOXIDE AT SUPERCRITICAL PRESSURE IN UNIFORMLY HEATED CIRCULAR TUBES

Protopopov, V.S., (Moskovskii Energeticheskii Institut, Moscow, USSR), Teplofizika Vysokikh Temperatur, V 15:815-821, July-Aug. 1977, In Russian, A78-12340
No abstract available

(EQUATIONS)

HP78 31013 STUDY OF A HIGH-PERFORMANCE EVAPORATIVE HEAT TRANSFER SURFACE, Final Report

Saaski, E.W., Hamasaki, R.H., (Sigma Research, Inc., Richland, WA), NASA-CR-152008, 82 p., 1977, NAS2-9120, N78-10411/4SL
An evaporative surface is described for heat pipes and other two-phase heat transfer applications that consists of a hybrid composition of V-grooves and capillary wicking. Characteristics of the surface include both a high heat-transfer coefficient and high heat-flux capability relative to conventional open-faced screw thread surfaces. With a groove density of 12.6 cm/l and ammonia working fluid, heat transfer coefficients in the range of 1 to 2 W/cm^2 have been measured along with maximum heat-flux densities in excess of 20 W/cm^2. A peak heat-transfer coefficient in excess of 2.3 W/cm^2 was measured with a 37.8 cm/l hybrid surface.

(AMMONIA, CONVECTIVE, EVAPORATIVE, FILM)

HP78 31014 CONDENSATION HEAT TRANSFER INSIDE ROTATING HEAT PIPES, Master's Thesis

Tantrakul, C., (Naval Postgraduate School, Monterey, CA),
103 p., 1977

An analytical study was undertaken to determine two-dimensional wall-conduction effects during film condensation on an internally finned rotating heat pipe. An earlier finite element method was modified to solve the problem by using different numbers of axial increments and different numbers of elements. Resulting heat transfer rates were shown to be similar to those obtained earleir. A rotating heat pipe was tested using various copper condensers, including two smooth-wall cylinders and a 0.5 degree truncated cone. All condensers were tested at different rotational speeds using distilled water as the working fluid. In the case of the 1.46 in diameter cylindrical condenser, data were also taken with Freon 113 and ethanol. The heat transfer rate of each condenser was plotted against the saturation temperature of the vapor. Using the experimental results obtained in this thesis, together with the data of earlier theses, a comparison was made with the theoretical analysis of Roetzel. Agreement is reasonable, and Roetzel's analysis can be used to predict overall rotating heat-pipe performance to within +-20 percent for water. The data for Freon 113 and ethanol, however, fall approximately 35 percent higher than this theory.

(ANALYTICAL STUDY, COPPER CONDENSERS, ETHANOL, EXPERIMENTAL STUDY, FREON 113, WATER)

IV. DESIGN, DEVELOPMENT, AND FABRICATION

IV. A. GENERAL

HP78 40005 INVESTIGATION OF THE CRITICAL REGION OF HEAT AND MASS TRANSFER IN LOW-TEMPERATURE WICKLESS HEAT PIPES

Bezrodnyi, M.K., Alekseenko, D.V., (Kievskii Politekhnicheskii Institut, Kiev, Ukrainian SSR), Teplofizika Vysokikh Temperatur, V 15:370-376, March-April 1977, High Temperature, V 15:309-313, N2, Sept. 1977, Translation, A78-19266
No Abstract available

(FREON, METHYL ALCOHOL, WATER, WORKING FLUID)

HP78 40006 DEVELOPMENT OF A JET PUMP-ASSISTED ARTERIAL HEAT PIPE, Final Report

Bienert, W.B., Ducao, A.S., Trimmer, D.S., (Dynatherm Corp., Cockeysville, MD), NASA CR-152,015, May 1977, NASA contract, DTM-77-2, NAS2-9233
Avail:TAC

This report describes the development of a jet pump-assisted arterial heat pipe. This new concept promises a solution to the problem of starting arterial heat pipes, in particular, those using high pressure working fluids, such as ammonia. The concept utilizes a built-in capillary-driven jet pump to remove vapor and gas from the artery and to prime it. The continuous pumping action also prevents depriming during operation of the heat pipe. The concept is applicable to fixed conductance and gas-loaded variable-conductance heat pipes. The report presents a theoretical model for the jet pump-assisted arterial heat pipe. The model was used to design a prototype for laboratory demonstration. The 1.2 m-long heat pipe was designed to transport 500 watts and to prime at an adverse elevation of up to 1.3 cm. The test results were in good agreement with the theoretical predictions. The heat pipe carried as much as 540 watts and was able to prime up to 1.9 cm. Introduction of a considerable amount of non-condensible gas had no adverse affect on the priming capability.

(AMMONIA, CAPILLARY JET-PUMP, GRAVITY, PRIMING, VENTURI)

HP78 40007 DESIGN AND DEVELOPMENT OF A HEAT PIPE DIODE, Phase 1, DESIGN, Final Report

Groll, M., Muenzel, W.D., (Stuttgart Univ., Energy Conversion and Heat Transfer Div., Stuttgart, W. Germany), N-78-11364

The analysis and design of a heat pipe thermal diode is described. The state-of-the-art of heat pipe technology, especially heat pipe diode technology, are reviewed. A number of design concepts is defined and subjected to a preliminary analysis. As a result of the evaluation and comparison of the various design concepts, an all-aluminum axial-groove ammonia-diode heat pipe, employing the liquid-trap principle, was selected. A 0-G forward-mode maximum performance of the diode wick of 194 W was predicted at an operating temperature of 20 C. This corresponds to a heat transport capability of 5820 W/cm. The predicted reverse-mode conductance for complete shutdown diode at a temperature difference between normal condenser section and normal evaporator-trap section of 40 K is 0.0286 W/K. The shutdown ratio was calculated to be 384. Instrumentation and test setup, as well as test procedures to experimentally determine forward and reverse-mode behavior of the heat pipe diode are described. A detailed manufacturing and assembly plan was developed.

(ALUMINUM, AMMONIA, TEMPERATURE CONTROL, THERMAL DIODE)

HP78 40008 SOME PROBLEMS OF DEVELOPING AND INVESTIGATING HEAT PIPES

Kazakov, E.A., Kodyukov, V.M., Mazilin, I.M., Chechurov, V.A., Radiats. Tekh., V 8:62-73, 1972, In Russian

Heat tubes for heat transfer without a temperature drop are studied. The heat tube design is given. Depending on the working temperature, the tubes are subdivided into low, medium, and high-temperature ones. The calculation of the maximum power transferred is given. Such questions as the choice of a capillar structure design and a coolant,the heat tube operation, and their fields of application are considered.

(CAPILLARY FLOW, NOMOGRAPHS, NUMERICAL SOLUTION, WORKING FLUID)

HP78 40009 HEAT PIPE CONTAINING A BODY PARTIALLY FILLED WITH A LIQUID HEAT-TRANSFER AGENT AND WITH A PINCHED CHARGING TUBE

Solodovnikov, Y.F., Frolikov, L.D., Brutyan, V.G., USSR, 1977

No abstract available

IV. B. WICKS

HP78 41004 CAPILLARY STRUCTURE FOR HEATING TUBES

Rohner, P., Schieferdecker, F.D., Germany, 1977, 9 p.
No abstract available

(WICK)

HP78 41005 PERFORMANCE OF AN EVAPORATIVE HEAT TRANSFER WICK

Saaski, E.W., Franklin, J.L., (Sigma Res., Inc., Richland, WA), Chem. Eng. Prog., V 73:47-77, N7, 4 refs, July, 1977

Thin-film evaporation, a particularly effective method for heat and mass transfer, finds application in numerous industrial processes. The investigations discussed here were primarily oriented toward improving evaporative heat transfer in heat pipes, although this evaporative technique is applicable to many other systems as well. Two techniques now used for fluid distribution involve either a felt-metal or a wire-cloth wick. Each is essentially a fine-pored metal capillary material that is tightly held against the wall. A theoretical analysis of inverted meniscus operation is followed by a description of an experimental test, in which the performance of the inverted meniscus surface in an evaporator was studied. Results are presented, which show that the inverted meniscus evaporator permits marked increases in radial heat transfer capacity.

(MENISCUS WICK, RADIAL HEAT TRANSFER)

IV. C. MATERIALS

HP78 42001 EFFECT OF THE DIAMETER AND LENGTH OF FIBERS ON CARCASS HEAT CONDUCTIVITY OF METAL FIBER WICKS OF HEAT PIPES

Semena, M.G., Zaripov, V.K., (Kiev Polytech Inst., Ukr SSR), Teploenergetika, p. 82-84, N4, 14 refs, April 1977, In Russian

Results of investigations regarding the effect of the diameter and length of sintered copper fibers on carcass heat conductivity of heat pipe wicks are presented. The diameter of the discrete mono-dispersed fibers was 20, 40, and 70 μm, and the length was three and 10 mm. The temperature range was 16-35 C. Formulas are proposed for the calculation of the carcass and effective heat conductivity of metallic fiber wicks of heat pipes.

(EQUATIONS, PARAMETRIC STUDY)

V. TESTING AND OPERATION

HP78 50006 EXPERIMENTAL INVESTIGATIONS ON SODIUM-FILLED HEAT PIPES

Dorner, S., Reiss, F., Schretzmann, K., (NASA, Washington, D.C.), NASA-TM-75144, Kerforschungzentrum, Karlsruhe, W. Germany, Rept. no. KFK-512, p. 1-21, Jan. 1967, Transl. into English from Experimentelle Untersuchungen an Natrium-Gefuellten Heat Pipes, Karlsruhe, W. Germany, NASW-2791, N78-12362

The possibilities of producing heat pipes, and especially the necessary capillary structures, are discussed. Several types of heat pipes were made from stainless steel and tested at temperatures between 400 and 1055 D. The thermal power was determined by a calorimeter. Results indicate bubble-free evaporation of sodium from rectangular open channels is possible with a heat flux of more than 1,940 W/cm^2 at 1055 C. The temperature drop along the tube could be measured only at low temperatures. A subdivided heat pipe worked against the gravitational field. A heat pipe with a capillary structure made of a rolled screen was supported by rings and bars operated at 250 W/cm^2 heat flux in the evaporating region.

(CAPILLARY TUBES, HEAT TRANSFER, STAINLESS STEEL, TESTING)

HP78 50007 PERFORMANCE INVESTIGATIONS OF LIQUID-METAL HEAT PIPES FOR SPACE AND TERRESTRIAL APPLICATIONS

Kemme, J.E., Keddy, E.S., Phillips, J.R., (Univ. of California, Berkeley, CA), (Los Alamos Scientific Lab., Los Alamos, NM)
Avail:TAC

The high heat transfer capacity of liquid-metal heat pipes is demonstrated in performance tests with mercury, potassium, sodium, and lithium working fluids and wick structures which serve to minimize liquid pressure losses and vapor-liquid interactions. Appropriate wicks for horizontal and vertical operation are described. It is shown that heat-transfer with these wicks is limited by vapor-flow effects. Examples are given of particular effects associated with a long adiabatic section between evaporator and condenser, and with a heat source of uniform temperature as opposed to a source of uniform power.

(LITHIUM, MERCURY, POTASSIUM, SODIUM, WICKS, WORKING FLUID)

HP78 50008 ANALYSIS OF HEAT PIPE PERFORMANCE USING INFRARED THERMOGRAPHY

Roberts, C.C.Jr., (Bell Lab., Naperville, IL), Proc. of the Bienn Infrared Inf. Exch., 3rd, St. Louis, MO, p. 127-135, Aug. 24-26, 1976, Publ. by AGA Corp., Secaucus, NJ, 1977

A heat pipe is a high thermal conductance structure, utilizing vaporization and condensation of a working fluid to obtain efficient heat transfer. There is considerable experimental research being performed in heat pipe fields due to many promising applications. Analyzing heat pipe performance often requires surface temperature measurements to verify its thermal conductance capability. The application of infrared thermography is especially useful, since it is a non-contact temperature-measurement technique, and yields a vast amount of temperature information on a device whose operating characteristics are relatively unknown. This paper describes various methods of utilizing infrared thermography to obtain heat pipe performance data. Methodology concerning heat pipe evaporation efficiency, heat pipe noncondensable gas generation, performance analysis in a gravitational environment, and analysis of a variable conductance heat pipe is presented.

(EXPERIMENTAL ANALYSIS, TEMPERATURE MEASUREMENT, THERMAL CONDUCTANCE, VARIABLE CONDUCTANCE)

HP78 50009 STEADY AND START-UP CHARACTERISTICS OF A HEAT PIPE WITH WICKLESS TANK

Semena, M.G., Baturkin, V.M., Rassamakin, B.M., (Kievskii Politekhnicheskii Institut, Kiev, Ukrainian SSR), Inzhenerno-Fizicheskii Zhurnal, V 33:381-387, Sept. 1977, In Russian, A78-18994

An experimental study of the transient and steady-state characteristics of a nitrogen gas-controlled heat pipe with wickless external tank is reported. Experiments were conducted in the range of transmitted heat fluxes 30-1200W and cooling temperature range 10-65 C, and three temperature levels determined by the mass of the noncondensing gas. The working fluid was water. The minimum load at which the heat pipe works in the control region was in the range 30-120 W, and depended on the design of the transport region and cooling conditions. A system of design equations for a heat pipe of this type was derived on the basis of a model of a plane vapor-gas front.

(DESIGN EQUATIONS, NITROGEN, WATER)

HP78 50010 ACCELERATED LIFE TESTS OF SPECIMEN HEAT PIPE FROM COMMUNICATION TECHNOLOGY SATELLITE (CTS) PROJECT

Tower, L.K., Kaufman, W.B., (NASA, Lewis, Cleveland, OH),
NASA-TM-73846, Dec. 1977, E-9433
Avail:TAC

A gas-loaded variable-conductance heat pipe of stainless steel with methanol working fluid, identical to one now on the CTS satellite, was life tested in the laboratory at accelerated conditions for 14,200 hours, equivalent to about 70,000 hours at flight conditions. The noncondensible gas inventory increased about 20 percent over the original charge. The observed gas increase is estimated to increase operating temperature by about 2.2 C, insufficient to harm the electronic gear cooled by the heat pipes in the satellite. Tests of maximum heat input against evaporator elevation agree well with the manufacturer's predictions.

(CORROSION, CTS SATELLITE, METHANOL, STAINLESS STEEL, THERMAL CONTROL)

HP78 50011 PARAMETRIC PERFORMANCE OF A SPIRAL-ARTERY, LIQUID LIQUID-TRAP DIODE HEAT PIPE

Williams, R.J., (NASA, Ames Res. Center, Moffett Field, CA),
NASA-TM-78448
Avail:TAC

This report describes a series of parametric investigations to determine the effect of various fluid charges on the performance of a 0.635 cm-diameter, spiral-artery, liquid-trap diode in both the forward and reverse modes. Specific parameters, such as forward and reverse-mode conductances, shutdown times and energies, and recovery to forward-mode operation are evaluated for ethane as a working fluid in the temperature range 170 K to 220 K.

(CRYOGENIC, ETHANE, FORWARD MODE, RECOVERY, REVERSE MODE, SHUTDOWN)

HP78 50012 EFFECT OF PRESSURE OF THE INTERMEDIATE HEAT CARRIER ON CRITICAL HEAT FLUXES IN EVAPORATIVE THERMOSIPHONS

Bezrodnyi, M.K., Alekseenko, D.V., (Kiev Polytech. Inst., Ukr SSR), Izv. Vyssh. Uchebn Zaved Energ., p. 80-84, N4, 9 refs, April 1977, In Russian

Results of an experimental investigation of critical heat fluxes in closed two-phase thermosiphons, depending on geometric dimensions of the heat supply section and the pressure of the intermediate heat carrier (F-11, F-12, F-113, and methanol), are presented. The investigations are carried out within the range of pressures from the atmospheric to 0.8 P_{cr}. As a result of generalization of

experimental data, it is found that the character of dependence of the critical heat fluxes on the reduced heat pressure P/P_{cr} for the liquids considered is identical and differs but slightly from the appropriate relation for the boiling of liquids under large-volume conditions.

(CRITICAL HEAT-FLUX, HEAT TRANSFER)

HP78 50013 HEAT TRANSFER IN A CENTRIFUGAL HEAT PIPE

Kukharskii, M.P., Krivosheev, B.N., Kosheleva, G.V., Inzhenerno-Fizicheskii Shurnal, V 33:388-392, Sept. 1977, In Russian, A78-18995

The effect of thermal flux density and vapor pressure on heat transfer in a cylindrical centrifugal heat pipe was studied on a calorimetric test setup with convective heat feeding and removal. A copper heat pipe of 2.8-cm inner diameter was tested at a rotation frequency of 96 rev/sec, a mean condensate layer thickness of 0.3 mm, and thermal flux density in the heat transfer sections of 20-80 KW/m^2. It was found that as the thermal flux density and pressure increased, the rate of heat transfer increased. An empirical formula was obtained for the heat transfer coefficient in the heat transfer zone as a function of the parameters studied.

(CALORIMETRIC TEST, CONVECTION, FLUX DENSITY, VAPOR PRESSURE)

HP78 50014 STUDY OF A HIGH-PERFORMANCE EVAPORATIVE HEAT TRANSFER SURFACE, Final Report

Saaski, E.W., Hamasaki, R.H., (Sigma Research, Inc., Richland, WA), NASA-CR-152008, 82 p., 1977, NAS2-9120, N78-10411/4SL

An evaporative surface is described for heat pipes and other two-phase heat transfer applications that consists of a hybrid composition of V-grooves and capillary wicking. Characteristics of the surface include both a high heat-transfer coefficient and high heat-flux capability relative to conventional open-faced screw thread surfaces. With a groove density of 12.6 cm/l and ammonia working fluid, heat transfer coefficients in the range of 1 to 2 W/cm^2 have been measured along with maximum heat-flux densities in excess of 20 W/cm^2. A peak heat-transfer coefficient in excess of 2.3 W/cm^2 was measured with a 37.8 cm/l hybrid surface.

(AMMONIA, CONVECTIVE, EVAPORATIVE, FILM)

HP78 50015 CRISIS OF HEAT AND MASS TRANSFER IN CLOSED-LOOP TWO-PHASE THERMOSIPHONS EMPLOYED IN COOLING METALLURGICAL FURNACES

Bezrodnyy, M.K., Koloskova, N.Y., (Kiev Polytech Inst., Ukr. SSR), Heat Transfer Sov. Res., V 8:99-103, N4, 4 refs, July-Aug. 1976

Experimental results on the heat transfer capacity of annular and circular thermosiphons with a duct for returning the condensate to the heated zone are presented. It is found that the duct improves significantly the heat-transfer capacity of the thermosiphon. The efficiency of cooling by wickless heat pipes (thermosiphons) was determined for blast furnaces, as well as for open-hearth furnaces.

(ARTERY WICK, FURNACE, HEAT TRANSFER)

INDEX OF AUTHORS

ADAMS, G.H.	020006
ALEKSEENKO, D.V.	031009
ALEKSEENKO, D.V.	050012
ALEKSEENKO, D.V.	040005
ALEXOVICH, R.E.	023010
BAKHNEV, V.G.	031011
BARTKEVICH, N.Y.	031011
BASIULIS, A.	022036
BATURKIN, V.M.	050009
BECKER, F.J.	023011
BECKER, F.J.	024004
BERDAHL, C.M.	021009
BERDAHL, C.M.	022026
BEZRODNYI, M.K.	031009
BEZRODNYI, M.K.	050012
BEZRODNYI, M.K.	040005
BEZRODNYY, M.K.	050015
BIENERT, W.B.	040006
BLOOM, A.M.	022033
BRISBANE, T.W.C.	022027
BRUTYAN, V.G.	040009
BUEHL, W.M.	022030
CAMARDA, C.J.	023012
CHALMERS, B.J.	024001
CHECHUROV, V.A.	040008
CHUBB, T.A.	022035
CHUBB, T.A.	021007
COTTER, D.	020002
DANIELS, T.C.	030010
DILATUSH, E.	024002
DORNER, S.	050006
DOSHI, M.R.	030011
DUCAO, A.S.	040006
DUMINIL, M.M.	010006
EASTMEN, G.Y.	030011
EWELL, G.J.	022036
FOSTER, G.H.	022029
FRANKLIN, J.L.	041005
FRITZ, C.H.	023013
FROLIKOV, L.D.	040009
GRAVES, J.R.	024003
GROLL, M.	040007
HAMASAKI, R.H.	031013
HAMASAKI, R.H.	050014
HANNA, D.C.	020002
HERMAN, J.	024001
HOWELL, R.H.	022028
IVANOVSKII, M.N.	030012
JACOBSON, D.L.	020003
KAUFMAN, W.B.	050010
KAZAKOV, E.A.	040008
KEDDY, E.S.	050007
KEMME, J.E.	050007
KODYUKOV, V.M.	040008
KOLOSKOVA, N.Y.	050015
KOSHELEVA, G.V.	050013
KOSHELEVA, G.V.	031010
KOTANI, K.	022031
KREEB, H.	023014

PAGE 36 INTENTIONALLY BLANK

INDEX OF TITLES/KEYWORDS (PERMUTED)

PAGE 34 INTENTIONALLY BLANK

HEAT PIPE RELATED PATENTS

PATENTS

PAGE 46 INTENTIONALLY BLANK

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U.S. PATENT 4082109
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00010 DANCY, E.A. VANSANT, J.H.
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HEATING SYSTEM
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HEAT TRANSFER
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MAY 23, 1978

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SENSI, J.E.
APPARATUS AND METHOD USING HEAT PIPES FOR MANIPULATING TEMPERATURE GRADIENTS IN A GLASS FORMING CHAMBER
U.S. PATENT 4092140
MAY 30, 1978

INDEX OF TITLES (PERMUTED)

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00009                       HEAT PIPE ACTUATED VALVE#
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00015 T PIPES FOR MANIPULATING TEM/ APPARATUS AND METHOD USING HEA
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00013                               HEAT PIPE ASSEMBLY#
00012       PROCESS FOR PRODUCING A HEAT PIPE#
00015 M/ APPARATUS AND METHOD USING HEAT PIPES FOR MANIPULATING TE
00010        FABRICATION OF CERAMIC HEAT PIPES#
00014                               HEAT TRANSFER#
00011                               HEATING SYSTEM#
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00015 NIPULATING TEM/ APPARATUS AND METHOD USING HEAT PIPES FOR MA
                                        'OF ' NOT INDEXED
00009                           HEAT PIPE ACTUATED VALVE#
00013                           HEAT PIPE ASSEMBLY#
00012  PROCESS FOR PRODUCING A HEAT PIPE#
00015 PARATUS AND METHOD USING HEAT PIPES FOR MANIPULATING TEMPERA
00010   FABRICATION OF CERAMIC HEAT PIPES#
00012 IPE#                          PROCESS FOR PRODUCING A HEAT P
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00011                        HEATING SYSTEM#
00015 G HEAT PIPES FOR MANIPULATING TEMPERATURE GRADIENTS IN A GLA
00014                           HEAT TRANSFER#
00015 ING TEM/ APPARATUS AND METHOD USING HEAT PIPES FOR MANIPULAT
00009             HEAT PIPE ACTUATED VALVE#
```

INDEX OF AUTHORS

PAGE 54 INTENTIONALLY BLANK

00013	ANDERSON, J.H.
00011	ASSELMAN, G.A.A.
00009	BASIULIS, A.
00015	CERUTTI, R.L.
00010	DANCY, E.A.
00012	HATAE, M.
00015	HENRY, V.I.
00011	MEIJER, R.J.
00014	SARCIA, D.S.
00012	SATA, T.
00015	SENSI, J.E.
00012	SHINODA, N.
00009	SUN, T.H.
00012	TAKAMURA, M
00011	VANDERAA, H.H.M.
00010	VANSANT, J.H.
00013	WATERS, E.D.

PAGE 57 INTENTIONALLY BLANK

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00011 U.S. PATENT 4034376#
00009 U.S. PATENT 4082109#
00010 U.S. PATENT 4082863#
00012 U.S. PATENT 4087893#
00013 U.S. PATENT 4090555#
00014 U.S. PATENT 4091264#
00015 U.S. PATENT 4092140#

INDEX OF PATENT NUMBERS

PAGE 58 INTENTIONALLY BLANK